

## Listener-directed contrastive hyperarticulation in voicing-conditioned vowel duration

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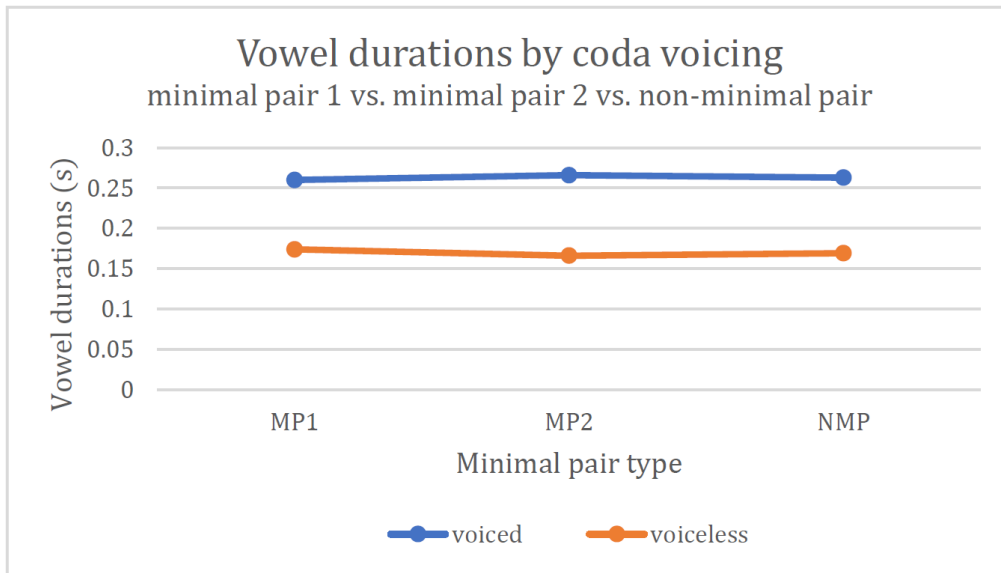
While it is well established that lexical competition conditions variation in phonetic realization, there have been various explanations for the mechanisms involved. Vowel hyperarticulation in high neighborhood density words has been interpreted as resulting from a listener-directed mechanism in which confusable words are hyperarticulated to aid listeners [1]. However, such variation can also be explained via speaker-internal mechanisms related to lexical access [2]. When a target word has many simultaneously activated neighbors, the activation required for the target word to inhibit its neighbors is greater; this additional activation induces greater articulatory effort, resulting in e.g., more peripheral vowels.

Our experiment seeks to distinguish between these two mechanisms by looking at enhancement of vowel duration differences in coda-voicing minimal pairs in English. While voicing itself is the primary cue to coda voicing, listeners can also use the secondary cue of longer vowel durations in pre-voiced contexts to help distinguish e.g., *bad* from *bat* [3]. Our study addresses the mechanism in three ways. First, since vowel duration is not phonemic in English, it is not phonologically represented and thus could not be enhanced in confusable words under a speaker-oriented activation account; however, it could still be useful to a listener and therefore affected in a listener-oriented account. Second, all vowels could get longer, consistent with a speaker-internal mechanism where greater activation leads to stronger articulations; or, vowels before voiced consonants could get longer, while vowels before voiceless consonants get shorter, consistent with a listener-directed mechanism with distinctiveness as the goal. Third, we manipulate the salience of the minimal pair confusion by changing whether a target word is encountered before or after its minimal pair. We expect that words that follow their minimal pair will be enhanced to mitigate listener confusion.

Twenty native speakers of American English produced 100 monosyllabic English words: 50 words with coda-voicing minimal pairs (half with voiced codas—e.g. *dog*, half with voiceless codas—e.g. *dock*) and 50 words with no coda-voicing minimal pairs (half with voiced codas—e.g. *tub*, half with voiceless codas—e.g. *shut*). Crucially, minimal pair (MP) words were presented in sequence, with order of coda voicing within the pair counterbalanced. MP words produced first and second in the pair were coded MP1 and MP2, respectively. MP and NMP words were matched for lexical frequency and neighborhood density. Participants recruited via Amazon Mechanical Turk recorded words remotely.

A linear mixed effects model examined predictors of vowel duration. The model included fixed effects of coda voicing, minimal pair type (MP1, MP2, NMP), and their interaction, and a random effect of speaker. This model showed an expected main effect of coda voicing, with longer vowel durations preceding voiced codas than voiceless ones [est. = -.086,  $t = -19.716$ ,  $p < .0001$ ]. There was no main effect of minimal pair type; however, there was a coda voicing by minimal pair type interaction (Figure 1). With MP1 as the reference level, the coda voicing by minimal pair type interaction was not significant for NMP, but for MP2, the interaction was indeed significant [est. = -.015,  $t = -2.452$ ,  $p = 0.014$ ]. MP2 words exhibited lengthening for voiced coda words and shortening for voiceless coda words, relative to MP.

These results show that voicing-conditioned vowel duration is enhanced in lexically confusable contexts, in particular when minimal pair words follow their minimal pair. That the enhancement occurs in the saliently confusable MP2 context and that it can occur for a non-represented feature both suggest a listener-directed mechanism. Moreover, while a speaker-internal mechanism could explain how segments lengthen with greater activation, the finding that vowels also shorten in enhancement contexts cannot be straightforwardly explained as a result of activation. Instead, we take this result to indicate a listener-directed mechanism.



**Figure 1.** Vowel durations by coda voicing.

**References**

- [1] Wright, R. (2004). Factors of lexical competition in vowel articulation. In Local, J., Ogden, R., and Temple, R. (eds.), *Papers in Laboratory Phonology VI*. Cambridge University Press, Cambridge
- [2] Baese-Berk, M., & Goldrick, M. (2009). Mechanisms of interaction in speech production. *Language and cognitive processes*, 24(4), 527-554.
- [3] Raphael, L. J. (1972). Preceding vowel duration as a cue to the perception of the voicing characteristic of word-final consonants in American English. *The Journal of the Acoustical Society of America*, 51(4B), 1296-1303.